

INTERNATIONAL STANDARD

**Industrial communication networks – Fieldbus specifications –
Part 4-21: Data-link layer protocol specification – Type 21 elements**



THIS PUBLICATION IS COPYRIGHT PROTECTED
Copyright © 2023 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

IEC Secretariat
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

IEC publications search - webstore.iec.ch/advsearchform

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee, ...). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

IEC Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

IEC Products & Services Portal - products.iec.ch

Discover our powerful search engine and read freely all the publications previews. With a subscription you will always have access to up to date content tailored to your needs.

Electropedia - www.electropedia.org

The world's leading online dictionary on electrotechnology, containing more than 22 300 terminological entries in English and French, with equivalent terms in 19 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.



IEC 61158-4-21

Edition 3.0 2023-03

INTERNATIONAL STANDARD

**Industrial communication networks – Fieldbus specifications –
Part 4-21: Data-link layer protocol specification – Type 21 elements**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 25.040.40; 35.100.20; 35.110

ISBN 978-2-8322-6555-0

Warning! Make sure that you obtained this publication from an authorized distributor.

CONTENTS

FOREWORD.....	7
INTRODUCTION.....	9
1 Scope.....	10
1.1 General.....	10
1.2 Specifications	10
1.3 Procedures	10
1.4 Applicability	10
1.5 Conformance	10
2 Normative references	11
3 Terms, definitions, symbols and abbreviated terms.....	11
3.1 Reference model terms and definitions	11
3.2 Service convention terms and definitions	13
3.3 Common terms and definitions.....	14
3.4 Additional Type 21 definitions	17
3.5 Common symbols and abbreviations	17
3.6 Additional Type 21 symbols and abbreviations.....	18
4 Overview of the data-link protocol.....	18
4.1 General.....	18
4.2 Overview of medium access control	19
4.3 Service assumed from the physical layer	19
4.4 DLL architecture	20
4.4.1 General	20
4.4.2 DLL management (DLM) interface support function	21
4.5 Data type	22
4.5.1 General	22
4.5.2 Boolean.....	22
4.5.3 Unsigned integer	22
4.5.4 Signed integer	22
4.5.5 Octet String	23
4.5.6 Visible String	23
4.5.7 Time	23
4.6 Local parameters and variables	24
4.6.1 General	24
4.6.2 DLL configuration parameters	24
4.6.3 Queues to support data transfer	25
4.6.4 Variables to support SAP management.....	25
4.6.5 Variables to support local device information management.....	27
4.6.6 Variables and counter to support network information management.....	31
4.6.7 Variables and counter to support a device path information management.....	35
4.6.8 Variables, counters, timers, and queues to support path table management.....	39
5 General structure and encoding.....	39
5.1 Overview.....	39
5.2 MAPDU structure and encoding	39
5.3 Common MAC frame structure, encoding and elements of procedure.....	40
5.3.1 MAC frame structure.....	40

5.3.2	Elements of the MAC frame	40
5.3.3	Elements of the Type 21 DLPDU	41
5.4	Order of bit transmission	49
5.5	Invalid DLPDU	49
6	DLPDU structure and procedure	49
6.1	General.....	49
6.2	Common DLPDU Field	49
6.2.1	General	49
6.2.2	Version	50
6.2.3	Length	50
6.3	DL-DATA Transfer	50
6.3.1	DT DLPDU.....	50
6.4	DL-SPDATA Transfer.....	53
6.4.1	SPDT DLPDU	53
6.5	Network control messages	55
6.5.1	General	55
6.5.2	NCM_LA DLPDU	55
6.5.3	NCM_AT DLPDU	56
6.5.4	NCM_LS DLPDU	58
6.5.5	NCM_RS DLPDU.....	59
6.5.6	NCM_AR_DLPDU.....	60
6.5.7	NCM_AR DLPDU structure	60
7	DLE elements of procedure	61
7.1	Overall structure	61
7.2	DL-protocol machine (DLPM).....	61
7.2.1	Overview	61
7.2.2	Primitive definitions	61
7.2.3	DLPM state table.....	65
7.2.4	DLPM functions	68
7.3	DLL management Protocol.....	70
7.3.1	Overview	70
7.3.2	Primitive definitions	70
7.3.3	DLM state table	73
7.3.4	DLM functions	97
8	Constants and error codes.....	106
8.1	General.....	106
8.2	Constants	106
8.3	Data-link layer error codes.....	108
	Bibliography.....	109
	Figure 1 – Interaction of PhS primitives with DLE.....	19
	Figure 2 – Data-link layer architecture	21
	Figure 3 – Relationships of DLSAPs, DLSAP-addresses, and group DL-addresses.....	26
	Figure 4 – Common MAC frame format for Type 21 DLPDU.....	40
	Figure 5 – MAC frame format for other protocols.....	40
	Figure 6 – Version and Length field	41
	Figure 7 – DST_addr field.....	42

Figure 8 – SRC_addr field.....	43
Figure 9 – Frame Control Field	43
Figure 10 – Extension field	46
Figure 11 – DSAP field	47
Figure 12 – Source service access point field	48
Figure 13 – Length of group mask and extension information.....	48
Figure 14 – Group mask option field	48
Figure 15 – Common DLPDU field	50
Figure 16 – Building a DT DLPDU.....	50
Figure 17 – DT DLPDU structure	50
Figure 18 – SPDT DLPDU structure	54
Figure 19 – NCM_LA DLPDU structure	55
Figure 20 – DLL structure and elements	61
Figure 21 – State transition diagram of the DLPM.....	65
Figure 22 – State transition diagram of DLM	74
Table 1 – DLL components	20
Table 2 – UNSIGNED n data type	22
Table 3 – INTEGER n data type	23
Table 4 – DLE configuration parameters	24
Table 5 – Queues to support data transfer	25
Table 6 – Variables to support SAP management	26
Table 7 – Variables to support device information management.....	27
Table 8 – DL-entity identifier	27
Table 9 – Device flags	28
Table 10 – DLM state.....	28
Table 11 – Device Unique Identification	28
Table 12 – Unique identification of device connected to R-port1	29
Table 13 – Unique identification of device connected to R-port2	29
Table 14 – MAC address	29
Table 15 – Port information.....	30
Table 16 – Protocol version	30
Table 17 – Device type	31
Table 18 – Device description.....	31
Table 19 – Hop count.....	31
Table 20 – Variables to support managing network information.....	32
Table 21 – Topology	32
Table 22 – Collision count.....	32
Table 23 – Device count	33
Table 24 – Topology change count	33
Table 25 – Last topology change time.....	33
Table 26 – RNMP device UID	33
Table 27 – RNMS device UID	34

Table 28 – LNM device UID for R-port1.....	34
Table 29 – LNM device UID for R-port2.....	34
Table 30 – Network flags	35
Table 31 – Variables and counter to support managing path information.....	36
Table 32 – Hop count for R-port1 direction.....	36
Table 33 – Hop count for R-port2 direction.....	37
Table 34 – Preferred R-port	37
Table 35 – Destination R-port	37
Table 36 – In net count	38
Table 37 – In net time	38
Table 38 – Out net count	39
Table 39 – Out net time	39
Table 40 – Version and Length	42
Table 41 – Destination DL–entity identifier.....	42
Table 42 – Source DL–entity identifier	43
Table 43 – Frame control.....	44
Table 44 – Extension	47
Table 45 – Destination service access point	47
Table 46 – source service access point.....	48
Table 47 – DT DLPDU parameters.....	51
Table 48 – Primitives exchanged between DLS-user and DLE to send a DT DLPDU.....	52
Table 49 – Primitives exchanged between DLS-user and DLEs to receive a DT DLPDU	53
Table 50 – SPDT DLPDU Parameters.....	54
Table 51 – Primitive exchanged between DLS-User and DLEs to send an SPDT DLPDU	54
Table 52 – Primitives exchanged between DLS-user and DLEs to receive an SPDT DLPDU	55
Table 53 – NCM_LA DLPDU parameters.....	56
Table 54 – NCM_AT DLPDU parameters	57
Table 55 – NCM_LS DLPDU parameters.....	58
Table 56 – NCM_RS DLPDU parameters	59
Table 57 – NCM_AR DLPDU parameters	60
Table 58 – Primitives exchanged between DLPM and DLS-user.....	62
Table 59 – Parameters exchanged between DLPM and DLS-user.....	63
Table 60 – Primitives exchanged between DLPM and DLM.....	64
Table 61 – Parameters used with primitives exchanged between DLPM and DLM.....	65
Table 62 – DLPM state table.....	66
Table 63 – DLPM functions table	69
Table 64 – Primitives exchanged between DLM and DLS-user.....	71
Table 65 – Parameters used with primitives exchanged between DLM and DLS-user.....	72
Table 66 – Primitive exchanged between DLM and DMAC	72
Table 67 – Parameters used with primitives exchanged between DLM and DMAC	73
Table 68 – Primitive exchanged between DLM and DPHY.....	73
Table 69 – Parameters used with primitives exchanged between DLM and DPHY.....	73

Table 70 – DLM state table	75
Table 71 – DLM function table	97
Table 72 – DLL constants	107
Table 73 – Type 21 DLL error codes	108

Currently in preview, click buy full version

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**INDUSTRIAL COMMUNICATION NETWORKS –
FIELDBUS SPECIFICATIONS –****Part 4-21: Data-link layer protocol specification –
Type 21 elements**

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use, and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, accept IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the informative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

Attention is drawn to the fact that the use of the associated protocol type is restricted by its intellectual-property-right holders. In all cases, the commitment to limited release of intellectual-property rights made by the holders of those rights permits a layer protocol type to be used with other layer protocols of the same type, or in other type combinations explicitly authorized by its intellectual-property-right holders.

NOTE – Combinations of protocol types are specified in the IEC 61784-1 series and the IEC 61784-2 series.

IEC 61158-4-21 has been prepared by subcommittee 65C: Industrial networks, of IEC technical committee 65: Industrial process measurement, control and automation. It is an International Standard.

This third edition cancels and replaces the second edition published in 2019. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) changed Table 9, Table 15, Table 30, Table 34, Table 35, Table 43, Table 47, Table 48, Table 49, Table 58, and Table 61;
- b) changed Network Control Message Type;
- c) miscellaneous editorial corrections.

The text of this International Standard is based on the following documents:

Draft	Report on voting
65C/1202/FDIS	65C/1243/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

A list of all parts of the IEC 61158 series, published under the general title *Industrial communication networks – Fieldbus specifications*, can be found on the IEC web site.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under store.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

INTRODUCTION

This part of IEC 61158 is one of a series produced to facilitate the interconnection of automation system components. It is related to other standards in the set as defined by the "three-layer" fieldbus reference model described in IEC 61158-1.

The data-link protocol provides the data-link service by making use of the services available from the physical layer. The primary aim of this document is to provide a set of rules for communication expressed in terms of the procedures to be carried out by peer data-link entities (DLEs) at the time of communication. These rules for communication are intended to provide a sound basis for development in order to serve a variety of purposes:

- a) as a guide for implementors and designers;
- b) for use in the testing and procurement of equipment;
- c) as part of an agreement for the admittance of systems into the open systems environment;
- d) as a refinement to the understanding of time-critical communications within OSI.

This document is concerned, in particular, with the communication and interworking of sensors, effectors and other automation devices. By using this document together with other standards positioned within the OSI or fieldbus reference models, otherwise incompatible systems could work together in any combination.

The International Electrotechnical Commission (IEC) draws attention to the fact that it is claimed that compliance with this document may involve the use of a patent. IEC takes no position concerning the evidence, validity, and scope of this patent right.

The holder of this patent right has assured IEC that s/he is willing to negotiate licences under reasonable and non-discriminatory terms and conditions with applicants throughout the world. In this respect, the statement of the holder of this patent right is registered with IEC. Information may be obtained from the patent database available at <http://patents.iec.ch>.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights other than those in the patent database. IEC shall not be held responsible for identifying any or all such patent rights.

INDUSTRIAL COMMUNICATION NETWORKS – FIELDBUS SPECIFICATIONS –

Part 4-21: Data-link layer protocol specification – Type 21 elements

1 Scope

1.1 General

The DLL provides basic time-critical data communications between devices in an automated environment. Type 21 provides priority-based cyclic and acyclic data communication using an internal collision-free, full-duplex dual-port Ethernet switch technology. For wide application in various automation applications, Type 21 does not restrict the cyclic/acyclic scheduling policy in the DLL.

1.2 Specifications

This part of IEC 61158 describes:

- a) procedures for the timely transfer of data and control information from one data link user entity to a peer user entity, and among the data link entities forming the distributed data link service provider;
- b) procedures for giving communication opportunities based on ISO/IEC/IEEE 8802-3 MAC, with provisions for nodes to be added or removed during normal operation;
- c) structure of the fieldbus data link protocol data units (DLPDUs) used for the transfer of data and control information by the protocol of this document, and their representation as physical interface data units.

1.3 Procedures

The procedures are defined in terms of:

- a) the interactions between peer data link entities (DLEs) through the exchange of fieldbus DLPDUs;
- b) the interactions between a data link service (DLS) provider and a DLS-user in the same system through the exchange of DLS primitives;
- c) the interactions between a DLS-provider and a physical layer service provider in the same system through the exchange of Ph-service primitives.

1.4 Applicability

These procedures are applicable to instances of communication between systems that support time-critical communications services in the data link layer of the OSI or fieldbus reference models, and that require the ability to interconnect in an open systems interconnection environment. Profiles provide a simple multi-attribute means of summarizing implementation's capabilities, and thus its applicability to various time-deterministic communications needs.

1.5 Conformance

This document also specifies conformance requirements for systems implementing these procedures. This document does not contain tests to demonstrate compliance with such requirements.